MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EEN3096 –COMMUNICATION ELECTRONICS

(TE / RE)

09 FEBRUARY 2023
14.30 p.m - 16.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages excluding cover page with 4 questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given .
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Fig. Q1a shows a system of cascaded attenuators. The total attenuation is 20 dB.

(i) Determine the value of resistors R_1, R_2, R_3, and R_4. [12 marks]

(ii) Calculate V_{out}. [2 marks]

(iii) What does it means by 20dB attenuation? How would the system be affected with increasing attenuation? [1 + 1 marks]

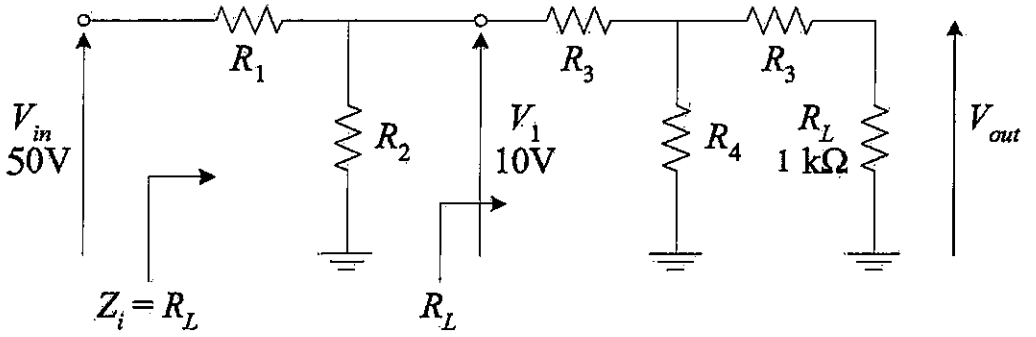

Fig. Q1a

(b) Fig. Q1b shows an L impedance matching network for a circuit with source impedance R_s = 100 Ω at resonant frequency 80 MHz.

(i) Determine the value of load resistance R_L. [5 marks]

(ii) Determine the value of the inductor L. [4 marks]

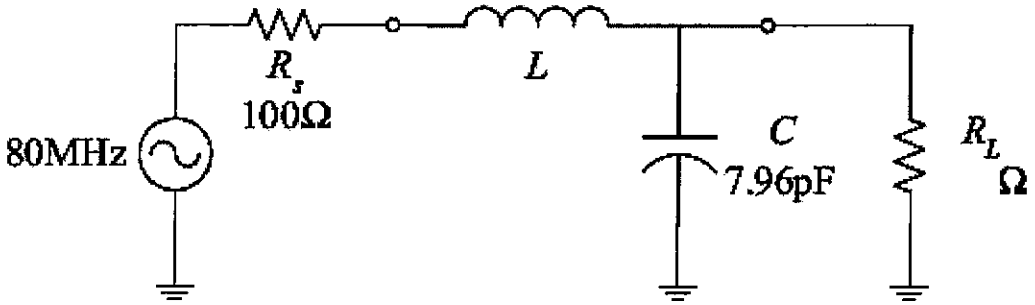

Fig. Q1b **Continued .....**

Question 2

(a) Explain three considerations in designing an RF amplifier. [6 marks]

(b) Define the term "transition frequency" in the context of amplifier design. [2 marks]

(c) Fig. Q2 shows a simple tuned amplifier. The amplifier is designed to operate at 15 MHz with an operating bandwidth of 1 MHz. The transistor has the following parameters: $r_{bb'} = 60\ \Omega$, $h_{fe} = 200$, $V_A = 50$ V, $C_c = 12$ pF, $f_T = 350$ MHz and $V_{BE} = 0.7$ V. The transistor is biased at $I_C = 5$ mA, $V_{CE} = 0.8\ V_{CC}$ and $I_{Rb1} = 0.1 I_C$.

(i) Determine the value of resistors R_{b1}, R_{b2} and R_e. [3 marks]

(ii) Draw the hybrid-π model of the circuit with Miller's capacitance. [5 marks]

(iii) Determine the value of all elements in the model drawn in part (ii). [6 marks]

(iv) Determine the voltage gain A_V (in dB) of the amplifier. [2 marks]

(v) How would the voltage gain A_V, affected with increasing load resistance R_L? [1 mark]

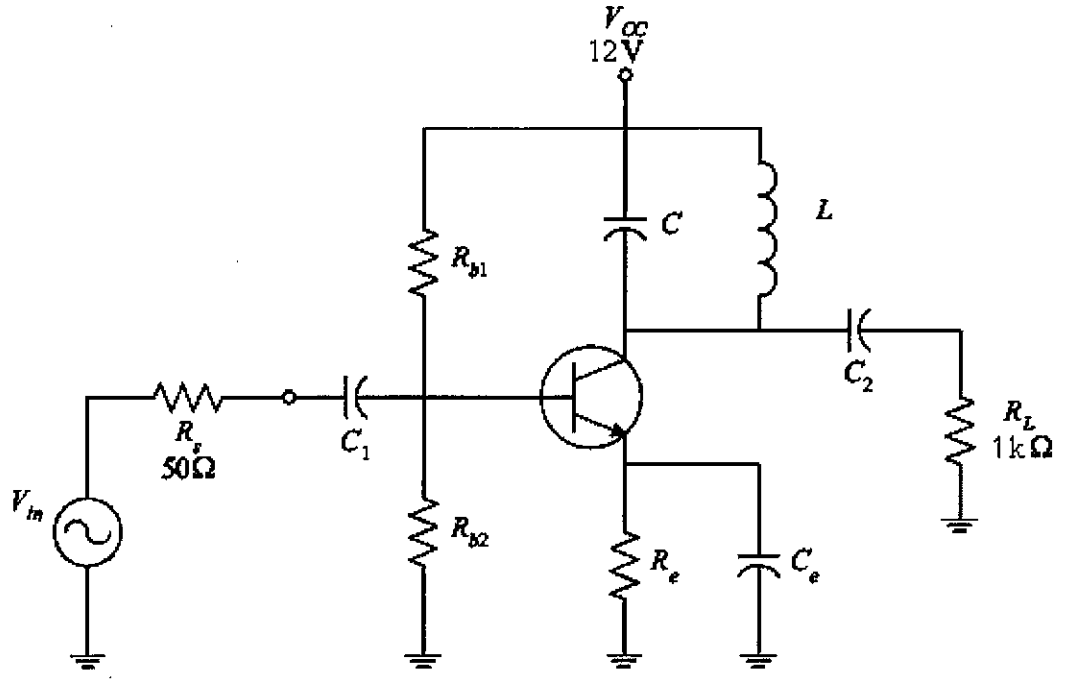

Fig. Q2

Continued .....

Question 3

(a) List out three essentials components of a phase locked loop (PLL). [3 marks]

(b) What is "capture range" and "lock range" in a PLL? [4 + 4 marks]

(c) A PLL with a VCO free-running frequency of 5 MHz has a 15% capture range and a 30% lock range. Over what frequency will the PLL able to capture and subsequently maintain lock?

[2 marks]

(d) Fig. Q3 provides some information to analyze the static behavior of a PLL. Determine:

(i) K_A of the amplifier. [1 mark]
(ii) The loop gain K_L in units of Hz/rad and decibels. [2 marks]
(iii) The loop gain K_v in units of s^{-1} and decibels. [2 marks]
(iv) The VCO output frequency when the system is locked. [1 mark]
(v) The static phase error, θ_e. [2 marks]
(vi) The hold-in range, Δf_H. [2 marks]
(vii) A, the maximum value of V_d. [2 marks]

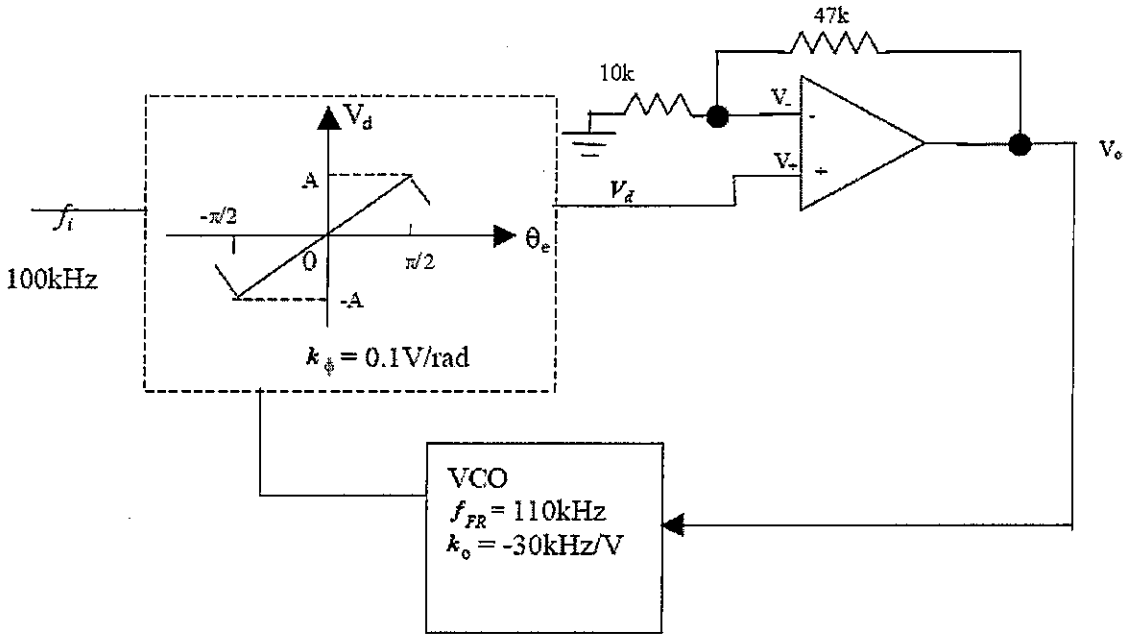

Fig. Q3

Continued .....

Question 4

(a) Explain the term "Automatic Gain Control (AGC)" in radio receiver and describe the functionality of it in radio receiver.

[2 + 3 marks]

(b) Sketch the block diagram of a superheterodyne receiver with an automatic gain control (AGC).

[11 marks]

(c) A double conversion receiver uses a first IF of 10.7 MHz and a second IF of 455 kHz, both with high tracking. For a signal is received at 40 MHz,

i) What are the LO frequencies? [3 marks]

ii) What are the outputs of first mixer? [3 marks]

iii) What are the signals going into the second mixer, and what signals come out of the second mixer?

[3 marks]

Continued .....

Appendix – Useful Formulas

1. L impedance matching network (when $R_L > R_s$):

$$B = \frac{X_L \pm \sqrt{R_L / R_s}\sqrt{R_L^{\,2} + X_L^{\,2} - R_s R_L}}{R_L^{\,2} + X_L^{\,2}} \qquad X = \frac{1}{B} + \frac{X_L R_s}{R_L} - \frac{R_s}{B R_L}$$

$$Q = \frac{|X|}{R_S}$$

2. L impedance matching network (when $R_L < R_s$):

$$B = \pm\frac{\sqrt{(R_s - R_L)/R_L}}{R_s} \qquad X = \pm\sqrt{R_L(R_s - R_L)} - X_L \qquad Q = R_S|B|$$

3. π impedance matching network:

$$L = L_1 + L_2 = \frac{R_I}{\omega_o}\left(\sqrt{R_S/R_I - 1} + \sqrt{R_L/R_I - 1}\right)$$

$$C_1 = \frac{1}{\omega_o R_S}\sqrt{\frac{R_S}{R_I} - 1} \qquad C_2 = \frac{1}{\omega_o R_L}\sqrt{\frac{R_L}{R_I} - 1} \qquad Q = \sqrt{\frac{R_S}{R_I} - 1} + \sqrt{\frac{R_L}{R_I} - 1}$$

4. RF Class A transistor amplifier (Hybrid π model of BJT)

$r_{bb'}$	**The base-spreading resistance.**
g_m	**The transconductance.** $g_m = \frac{dI_C}{dV_{BE}} = \frac{qI_C}{kT} \cong \frac{I_C(\text{in mA})}{25.875mV}$ at T=300K, q= electronic charge, $1.6\text{x}10^{-19}$C
C_e	**The emitter capacitance.**
$r_{b'e}$	**The input resistance.** $r_{b'e} = \frac{dV_{B'E}}{dI_B} = \frac{h_{fe}}{g_m}$
$r_{b'c}$	**The collector to base resistance.** $r_{b'c} = h_{fe}r_{ce}$
C_C	**The collector capacitance.**
r_{ce}	**The output resistance.** $r_{ce} \cong \frac{V_A}{I_C} = \frac{qV_A}{kTg_m}$ Where V_A is known as the Early voltage and I_C is the dc collector current.

Continued .....

5. High frequency Class A amplifier parameters:

(a) Voltage gain:

$$A_V = \frac{v_o}{v_{BE}} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + r_{b'e}} \frac{1}{1 + j\omega C_T \frac{r_{bb'} r_{b'e}}{r_{bb'} + r_{b'e}}}$$

In cases where $r_{bb'} << r_{b'e}$ then

$$A_V = \frac{v_o}{v_{BE}} = -\frac{g_m R_o}{1 + j\omega C_T r_{bb'}}$$

(b) Effective voltage gain (including the effect of source impedance Rs):

$$A_{VS} = \frac{v_o}{V_S} = -g_m R_o \frac{r_{b'e}}{r_{bb'} + R_S + r_{b'e}} \frac{1}{1 + j\omega C_T \frac{(R_S + r_{bb'}) r_{b'e}}{R_S + r_{bb'} + r_{b'e}}}$$

In cases where $(R_s + r_{bb'}) << r_{b'e}$ then

$$A_{VS} = \frac{v_o}{V_S} = -\frac{g_m R_o}{1 + j\omega C_T (R_S + r_{bb'})}$$

Where $C_T = C_e + C_M$ and C_M = Miller capacitance $C_M = (1 + g_m R_o) C_C$

(c) Transition frequency

$$f_T = \frac{1}{2\pi} \frac{g_m}{C_e + C_C}$$

(d) Input impedance

$$Z_I = r_{bb'} + \frac{r_{b'e}}{1 + j\omega r_{b'e} C_T}$$

End of Paper